February 28, 2020

<u>Ex Parte</u>

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Re: *Unlicensed Use of the 6 GHz Band*, ET Docket No. 18-295; *Expanding Flexible Use in Mid-Band Spectrum*, GN Docket No. 17-183

Dear Ms. Dortch:

On December 5, 2019, the National Association of Broadcasters ("NAB") submitted a report purporting to show that low-power indoor unlicensed operations in the 6 GHz band will cause harmful interference to 6 GHz wireless links used by broadcasters.[1] We responded to that filing on January 14, 2020, highlighting a number of major flaws in that study.[2] Most significantly, in the bands RLAN devices would share with broadcasters, the study included higher RLAN device power levels than any party has requested, included outdoor operations in bands where they have not been proposed, and assumed free-space propagation conditions across the board even in dense urban areas.[3] The Society of Broadcast Engineers ("SBE") subsequently submitted a filing agreeing with NAB's report, but not contributing any new engineering analysis or addressing the significant flaws we had already identified in NAB's filing.[4]

We have continued to work with NAB and its engineering consultant, Alion, to determine their reasons for including these erroneous assumptions and to better understand aspects of the study's methodology and inputs not fully disclosed by NAB's filing. We appreciate NAB's and Alion's willingness to discuss these issues with us, but, unfortunately, we still have not been able to obtain the information necessary to replicate NAB's study. In fact, given what we have learned, we reiterate our previous objections to that study—its assumptions were so wildly

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1 Mark Gowans and Martin Macrae, Alion Science and Tech., Analysis of Interference to Electronic News Gathering Receivers from Proposed 6 GHz RLAN Transmitters (2019) *as attached to* Letter from Rick Kaplan, General Counsel and Executive Vice President, Nat'l Ass'n of Broadcasters, to Marlene H. Dortch, Sec'y, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed Dec. 5, 2019) ("NAB Filing").

2 Letter from RLAN Group to Marlene H. Dortch, Sec'y, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed Jan. 14, 2020) ("RLAN Group Response to NAB").

3 *See id*.

4 Letter from Wayne Pecena, President, Soc'y of Broad. Eng'rs, et al., to Marlene H. Dortch, Sec'y, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 18, 2020) ("SBE Filing").

inaccurate that the Commission cannot rationally rely on it in evaluating the risk of harmful interference.

In addition to identifying these major flaws in NAB's study, we have also conducted our own analysis of the interference risk to the three categories of broadcast operations considered in NAB's filing: outdoor links from remote trucks to central receive sites, outdoor links from electronic newsgathering ("ENG") devices[5] to receivers on trucks, and indoor links between ENG transmitters and ENG receivers. In each case—using the scenarios considered in NAB's report—we confirm that there is no real-world risk of harmful interference.

I. OUTDOOR LINKS BETWEEN REMOTE TRUCKS AND CENTRAL RECEIVE SITES

Following the NAB report, we considered the potential for harmful interference from RLAN devices to Broadcast Auxiliary Service ("BAS") transmissions between trucks and central receive sites in San Diego, CA and Washington, DC. We conducted a Monte Carlo analysis that factored in the probability of line-of-sight from the BAS receiver to RLAN transmitter using the same receive sites used in the NAB report. However, unlike that analysis, we employed industry-standard propagation modeling and publicly available terrain/LiDAR data.[6]

We performed 100,000 Monte Carlo simulations each for six specific cases in each city, covering two different frequencies in U-NII-6 and U-NII-8 and three different central receive antenna orientations, as outlined in the NAB report. RLAN devices were randomly distributed in these study areas using the same methodology employed in both ECC Report 302 and the RKF report, but with an additional 10% instantaneously transmitting devices in rural areas.[7] We also applied the same methodology for determining the total number of active 6 GHz transmitters at any given time.[8] Using this methodology, we arrived at a total number of RLAN transmitters of 441,655 based on a projected 2025 U.S. population of 347,000,000.

As we have explained, RKF's assumptions already vastly exceed any reasonable projection of the likely number of RLAN devices operating in the 6 GHz band,[9] making these additional simulations purely informational. All of the available evidence suggests that they wildly overstated the number of instantaneously transmitting 6 GHz RLAN devices, even taking into account the rapid growth in demand for unlicensed connectivity.

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5 These devices are generally wireless microphones and cameras.

6 For small portions of the areas under study, no public LiDAR data is available. Our analysis covered areas where this data was available.

7 *See* RKF Eng'g, Frequency Sharing for Radio Local Area Networks in the 6 GHz Band 12-13 (2018), *as attached to* Letter from Paul Margie, Counsel, RLAN Group, to Marlene H. Dortch, Sec'y, FCC, GN Docket No. 17-183 (filed Jan. 26, 2018) ("RKF Report").

8 *See id*.

9 Letter from RLAN Group to Marlene H. Dortch, Sec'y, FCC, ET Docket No. 17-183 at 4 (filed May 14, 2018).

RLAN device heights, power levels, bandwidth, and use cases were assigned using the following distributions:

RLAN Use Cases by Geography

	Urban			**Suburban**			**Rural**		
	70%			10%			20%		
User Type	**Corp**	**Public**	**Home**	**Corp**	**Public**	**Home**	**Corp**	**Public**	**Home**
	10%	5%	85%	5%	5%	90%	2%	1%	97%

RLAN Device Heights by Geography and Use Case

		Urban Indoor			**Suburban Indoor**			**Rural Indoor**		
Story	Height (m)	Corp (%)	Public (%)	Home (%)	Corp (%)	Public (%)	Home (%)	Corp (%)	Public (%)	Home (%)
1	1.5	82.35	82.35	77.85	82.35	82.35	77.92	84.17	84.17	84.17
2	4.5	13.35	13.35	17.85	13.35	13.35	17.92	14.17	14.17	14.17
3	7.5	2.85	2.85	2.85	2.85	2.85	2.92	1.67	1.67	1.67
4	10.5	0.52	0.52	0.52	0.52	0.52	1.25	0.00	0.00	0.00
5	13.5	0.36	0.36	0.36	0.36	0.36	0.00	0.00	0.00	0.00
6	16.5	0.24	0.24	0.24	0.24	0.24	0.00	0.00	0.00	0.00
7	19.5	0.16	0.16	0.16	0.16	0.16	0.00	0.00	0.00	0.00
8	22.5	0.09	0.09	0.09	0.09	0.09	0.00	0.00	0.00	0.00
9	25.5	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00
10	28.5	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

RLAN Bandwidth Distribution

Bandwidth	**20 MHz**	**40 MHz**	**80 MHz**	**160 MHz**
Percentage	10%	10%	50%	30%

Indoor RLAN EIRP Distribution

Power (mW)	**1000**	**250**	**100**	**50**	**40**	**20**	**13**	**5**	**1**	**Total**
Indoor percentage	0.71	9.16	4.39	13.75	1.82	12.03	40.00	12.47	5.68	100.0

We appropriately restricted our analysis to indoor devices to reflect the indoor-only limitations on operation in these bands reflected in the NPRM. We applied the full ITU-R P.2109 building-entry loss distributions with a 30%/70% mixture of buildings using thermally efficient and traditional construction, respectively.[10]

The results of these simulations were clear: the risk of exceeding -6 dB I/N is less than 0.1%. It is critical to emphasize that this is not the probability that a given RLAN will cause harmful interference. It is the probability that, accounting for *all* the RLAN devices in a market, a configuration will occur that generates energy in excess of -6 dB I/N.

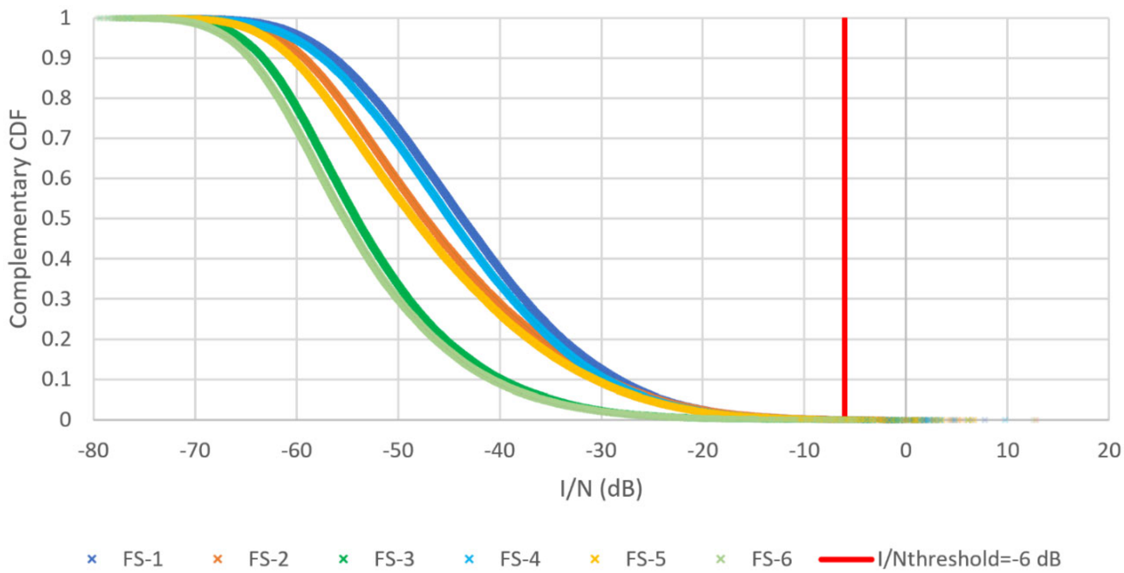

Figure 1 — Distribution of simulation results for Washington DC, Old Post Office location.

[10] *See* ITU-R, Recommendation P.2109-1: Prediction of Building Entry Loss 2-3 (2019) (describing thermally efficient versus traditional building construction).

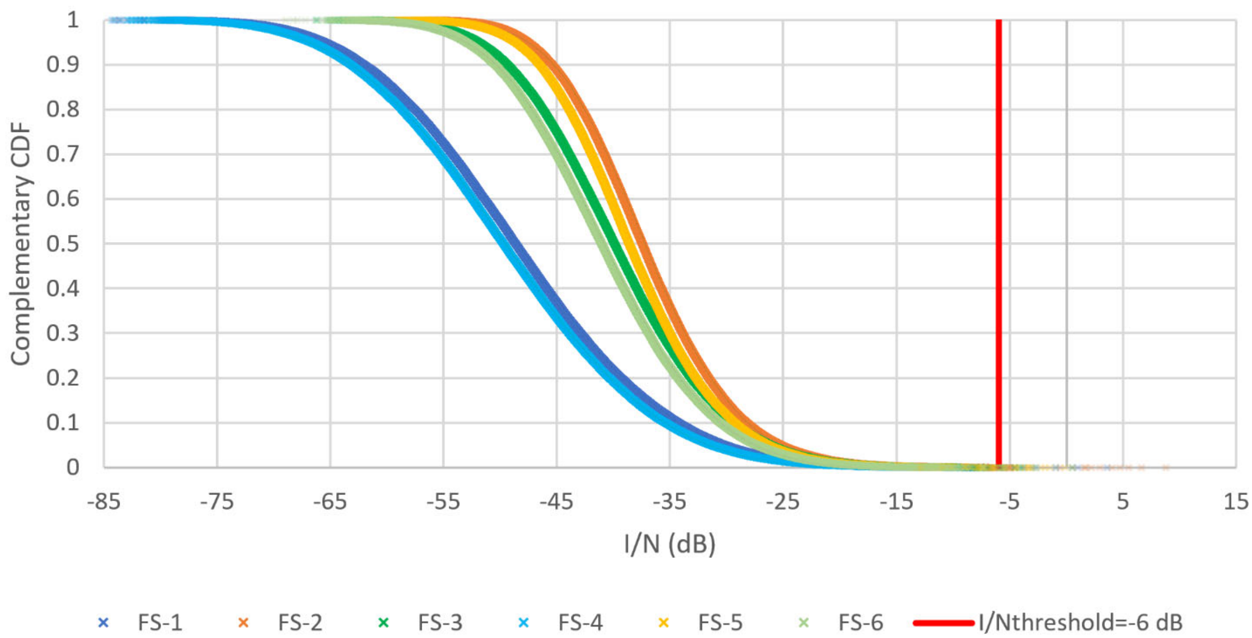

Figure 2 — Distribution of simulation results for Cowles Mountain location.

We found that one of the reasons for the low risk of interference into ENG central receive sites is because these antennas are located so high above surrounding terrain. This means that an RLAN signal would either be far outside of the main beam, or very far away and, in any case, extremely likely to be obstructed by buildings and other clutter. Notably, even in rare cases where the received I/N ratio could theoretically exceed -6 dB, harmful interference is extremely unlikely to occur and, if it does, this interference can readily be mitigated. For example, operators can typically increase receive power to improve the quality of a BAS link, if necessary. Although our results clearly indicate that this will be necessary only in extremely rare cases, if at all, even these hypothetical cases will have virtually no real-world effect.

At least one reason for the wide discrepancy between these results and those in the NAB report is, as we had predicted, serious errors in NAB's identification of areas where line of sight propagation can apply to the links. NAB's report indicates that, even in many densely populated areas with numerous tall buildings, ENG central receive sites at Cowles Mountain, outside San Diego, and at the Old Post Office in Washington, DC, would have line of sight to a majority (and in some cases close to 100%) of the population. This is implausible on its face, as any resident of the DC metro area knows—although there are some isolated places from which it is possible to see the top of the Old Post Office, line of sight is almost always blocked by buildings.

Our detailed LiDAR analysis confirmed this. As depicted below, we found that line of sight was rare, even in places where NAB claimed that as much as 90% to 100% of the population would have line of sight to the ENG receiver.

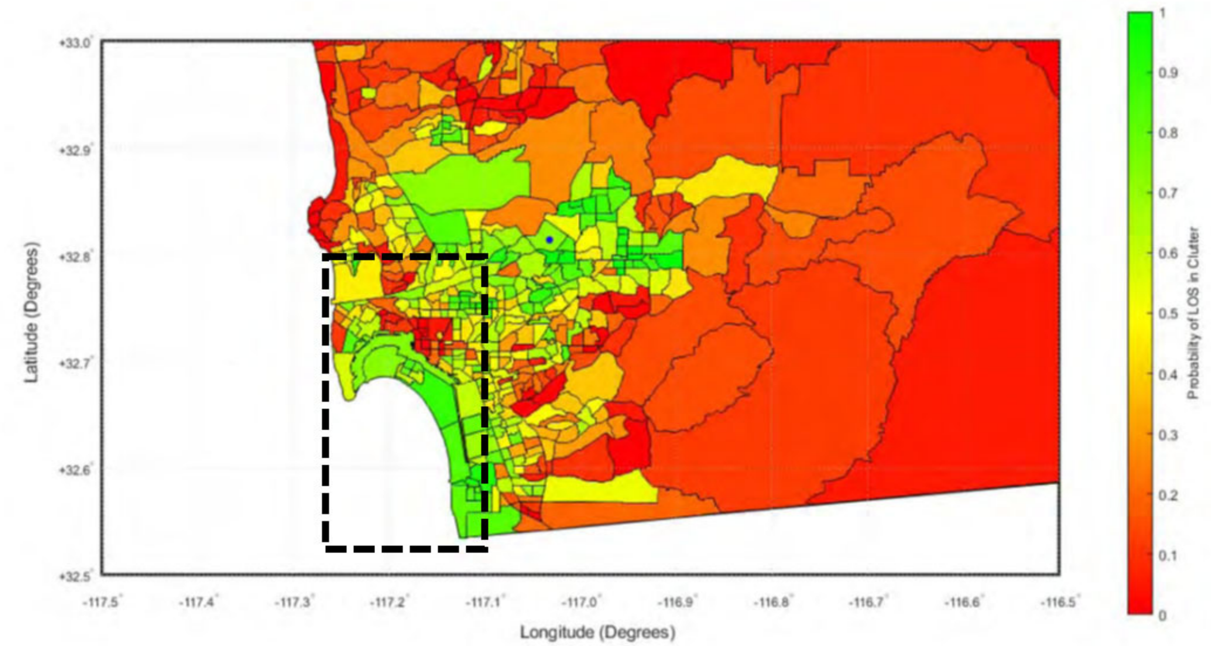

Figure 3 — NAB's per-census-tracts line-of-sight estimations for the San Diego, CA area. The area within the dashed lines is the area depicted in the corrected figure below

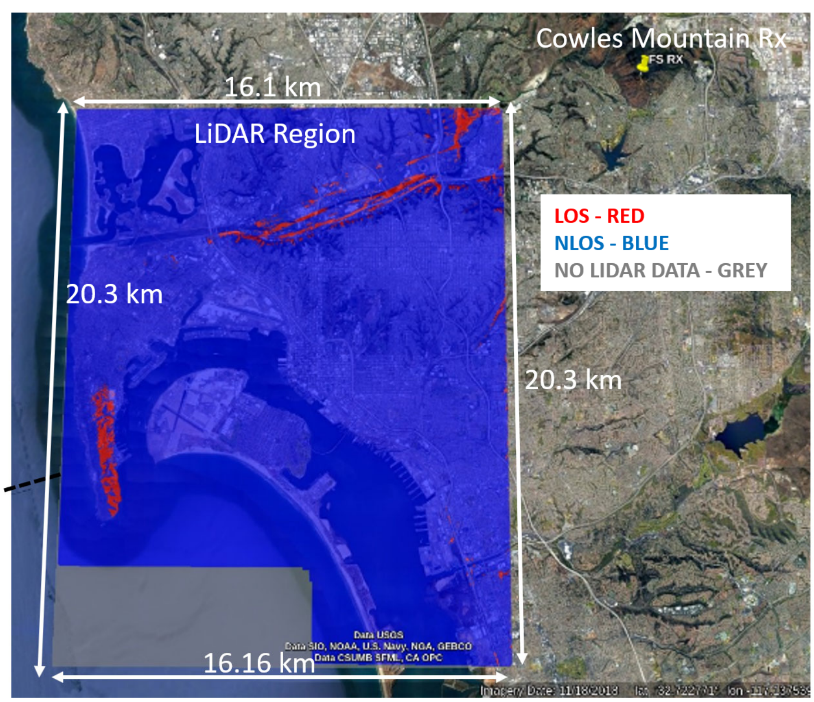

Figure 4 — Corrected San Diego, CA line-of-sight determinations—11x22 meter grid.

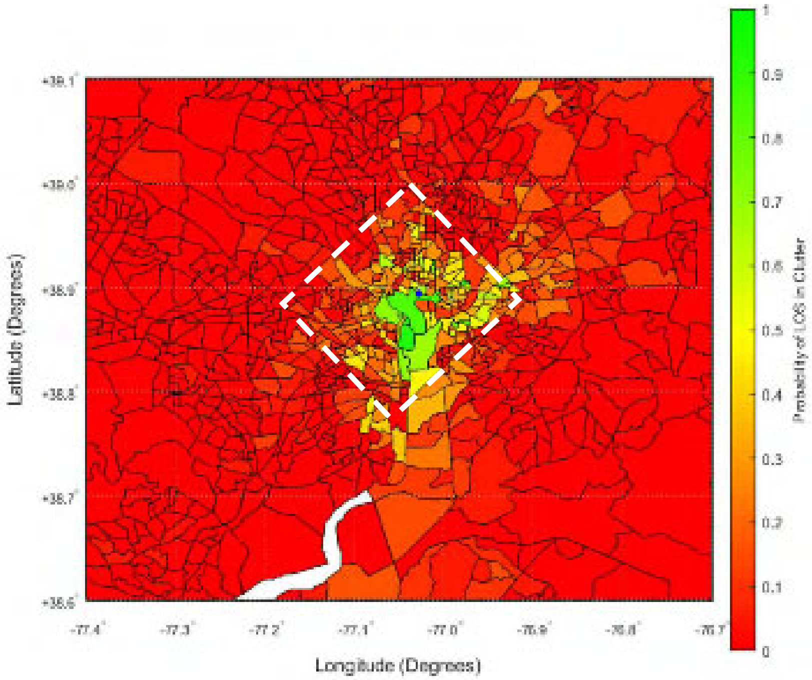

Figure 5 — NAB's per-census-tracts line-of-sight estimations for the Washington, DC area. The area within the dashed lines is the area depicted in the corrected figure below.

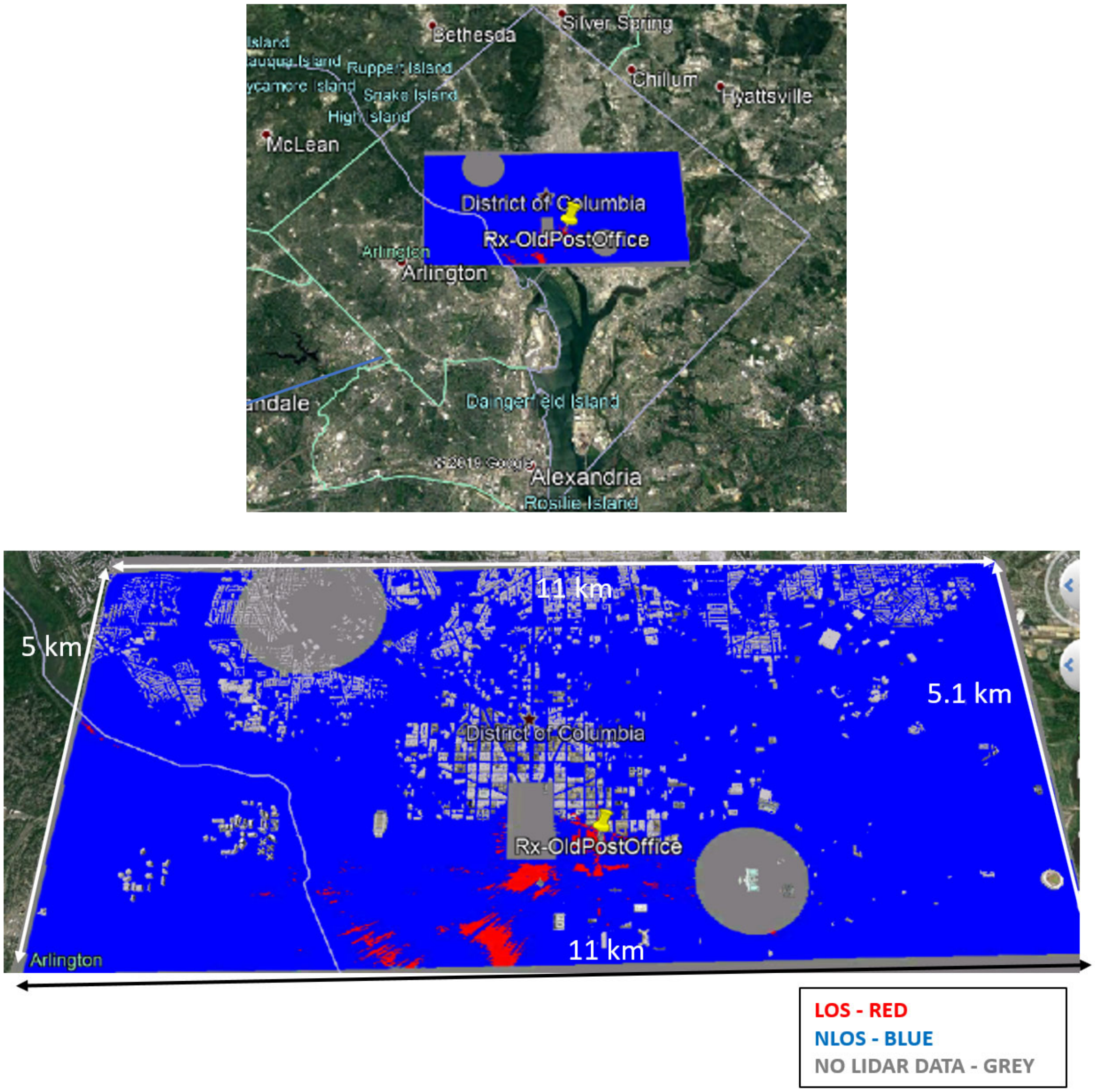

Figure 6 — Corrected Washington, DC line-of-sight determinations—11x22 meter grid.

II. Outdoor Links between Remote Trucks and Mobile ENG Transmitters

NAB has claimed that low-power indoor RLAN devices will cause harmful interference to ENG receivers in news trucks receiving signals from nearby microphones, camera-back transmitters, and other ENG devices. NAB hypothesizes that interference may occur in these situations because of the truck's proximity to buildings that may contain 6 GHz RLAN devices.

What NAB overlooks is that although these newsgathering trucks may be close to buildings, they will also be close to the wireless microphones and camera-back transmitters with whose signals RLANs will supposedly interfere. This physical proximity will result in very high received signal strengths of the desired signals, making harmful interference from low-power indoor RLANs further attenuated by building loss very unlikely.

To confirm this, we analyzed the same ENG-to-truck scenario that NAB considered outside of the Metropolitan Police Department headquarters in the Henry J. Daly building in Washington, DC. The results confirmed that, in NAB's chosen scenario, there is no real-world risk of harmful interference.

As depicted below, we considered an ENG transmitter located on the front steps of the building transmitting to a news truck located along C St. NW with line-of-sight to the central receive site located in the Old Post Office building. The ENG transmitter was assumed to transmit at a very low power level of 14 dBm (25 mW) with a 3 dBi antenna at a height of 2 meters and line of sight to the news truck. For the ENG receiver we assumed, consistent with NAB's report, that the truck would use a Vislink 9003561 sector antenna with 12 dBi of gain. We assumed that an RLAN was placed in the corner of each building and all four RLANs were operating co-channel with ENG. This is an extremely improbable event given that ENG camera-back radios typically operate on a 10 MHz channel, and there are three 20 MHz channels in 2.4 GHz (60 MHz), twenty five-20 MHz channels in 5 GHz (500 MHz), and fifty nine-20 MHz channels in 6 GHz (1180 MHz). The likelihood that one of the access points, let alone all four access points, are operating co-channel with ENG is very unlikely.

In this scenario, we concluded that the distance from the ENG transmitter to the receiver could range from 56 to 133 meters, with a nominal average distance of 94 meters. At these distances, the ENG signal would be received at SINRs of 18 - 43 dB factoring in possible RLAN noise.

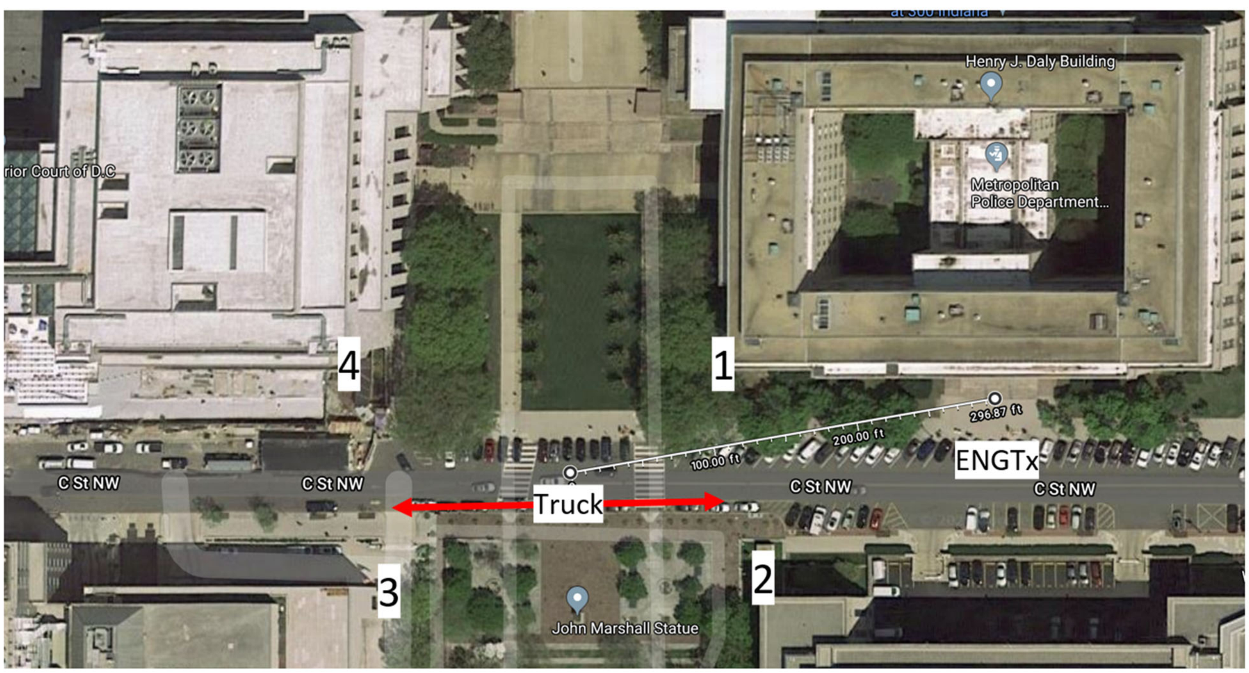

Figure 7 — Washington, DC outdoor ENG scenario. Worst-case RLAN placements identified with numbers 1-4.

The type of ENG receiver described in the NAB report would require an SINR of no more than 9 dB to perform at a 1e-8 bit-error-rate in the face of RLAN interference—assuming an abnormally high RLAN duty cycle, and worst-case configuration of the ENG link (8 MHz channel with 7/8 forward error correction).[11] This means that, even in the worst result for this scenario, an ENG receiver would have at least 9 dB more margin than required even in the unlikely case of an RLAN duty cycle greater than 99% of RLAN access points.[12]

In addition, ENG operators will have multiple options for mitigating any interference that occurs, in the extremely unlikely situation where an outdoor ENG link is affected. News truck operators will be able to improve their link budgets by slightly adjusting the positions of their trucks or shooting locations. For example, in the case we have evaluated, very small adjustments to the truck's location could improve SINR by 3 dB or more, even assuming *all four* APs were operating co-channel.[13] We have also assumed that the ENG transmitter would operate at only 14 dBm (25 mW). An operator could improve its SINR by another 6 dB by increasing power to 20 dBm (100 mW), which is a common capability of these transmitters.

Finally, it is important to note that the 6 GHz band is only one of many bands available to ENG operations. As the SBE acknowledges, for example, ENG spectrum is also available in the 2 and 2.5 GHz bands,[14] which for many applications have superior propagation characteristics to the 6 GHz band. Although SBE decries the congested state of these bands for ENG, SBE fails to disclose that ENG operations are increasingly moving away from dedicated ENG spectrum altogether, in favor of cellular connectivity or Wi-Fi.[15]

III. INDOOR ENG LINKS

The final category of broadcast operations described in NAB's report is communication between indoor ENG transmitters, such as microphones and camera-back transmitters, and indoor ENG receivers. NAB assessed the risk of harmful interference between RLAN devices

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[11] *See* Letter from Chris Szymanski, Director of Product Marketing and Government Affairs, Broadcom Inc., to Marlene Dortch, Sec'y, FCC, ET Docket No. 18-295 (filed Feb. 28, 2020).

[12] *See* CableLabs, 6 GHz Low Power Indoor (LPI) Wi-Fi / Fixed Service Coexistence Study, 16 (2019) *as attached to* Letter from Rob Alderfer, Vice President of Tech. Policy, CableLabs, to Marlene Dortch, Sec'y, FCC, ET Docket No. 18-295 (filed Dec. 20, 2019); Broadcom, Duty Cycle Data, *as attached to* Letter from Paul Margie, Counsel, RLAN Group, to Marlene Dortch, Sec'y, FCC, ET Docket No. 18-295 (filed Dec. 9, 2019).

[13] If only one or two of the four APs were operating co-channel with the ENG transmission, the truck would have far more flexibility to increase SINR with a slight adjustment.

[14] SBE Filing at 4.

[15] *See* Comments of Teradek, LLC and Amimon, Inc. at 1-2, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019); Ven Balakrishnan, *Strong Signals for Bonded Cellular in Broadcasting*, GRANT THORNTON (Sept. 4, 2019), https://www.grantthornton.co.uk/insights/strong-signals-for-bonded-cellular-in-broadcasting/ ("Our interviews suggest bonded cellular technology is currently used in up to 70% of live news broadcasts.").

installed in the House of Representatives Chamber and wireless microphones and cameras used by members of the press to cover the proceedings.

As we have pointed out, such a situation should not occur in the real world, because the manager of the venue can choose on which channels ENG and RLAN equipment should operate. The House of Representatives, in fact, presents an especially clear example of this because, in the House Chamber, both RLAN and ENG devices are centrally managed.[16]

In addition, NAB has not taken into account the behavior of RLAN devices in such a scenario. RLAN devices, including not just Wi-Fi but other technologies as well, have two features that will mitigate the risk of harmful interference.

First, RLAN devices account for their radiofrequency environment before selecting a channel of operation. Although specific channel-selection algorithms vary by vendor, the amount of noise on a channel is a key factor.[17] The greater the background noise, the lower the probability that an RLAN device will operate on that channel. In the example NAB highlights, and as further detailed below, ENG transmissions will generate extremely high levels of interference to RLAN devices, which will result in their selecting different channels of operation, preventing harmful interference to ENG receivers.

In addition, RLAN devices perform clear-channel assessments before transmitting. For Wi-Fi devices, the 802.11 specification dictates that devices sense the energy in the channel and not transmit if they detect energy at a level greater than -62 dBm.[18] To confirm that this behavior would be effective in preventing harmful interference in the scenario NAB highlighted, we conducted an additional simulation to determine the likelihood that an RLAN device would operate co-channel with an ENG transmitter in the House Chamber.

We assumed the most realistic scenario in NAB's report of 20 RLAN access points operating within the Chamber.[19] We accepted NAB's assumption that these devices could be distributed in a grid pattern throughout the Chamber. In addition, we determined the real-world locations of ENG cameras in the House Chamber, which was readily ascertained through visual inspection. The spatial arrangement of RLAN devices and ENG transmitters is illustrated below.

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16 RLAN Group Response to NAB at 2.

17 *See, e.g.*, Qualcomm Atheros, Automatic Channel Selection, https://w1.fi/cgit/hostap/plain/src/ap/acs.c (last visited Feb. 25, 2020) (providing an open-source implementation of a Wi-Fi channel-selection algorithm in which channels are weighted using a number of factors, including an "interference factor"). The interference factor is driven by multiple variables, but increases exponentially with in-channel noise, such that operation on a channel with noise of -62 dBm or greater is heavily disfavored.

18 IEEE Standards Ass'n., 802.11-2016 Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications 17.3.10.6 (2016).

19 NAB Filing at 19.

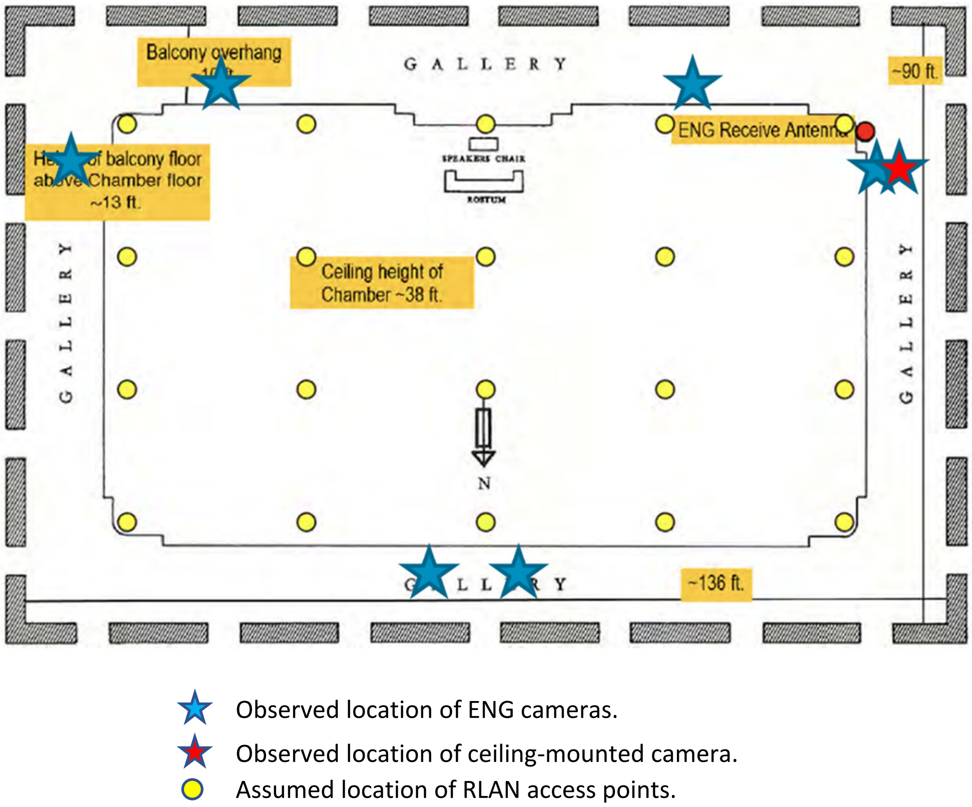

Figure 8 — Possible configuration of ENG transmitters and RLAN devices in the chamber of the U.S. House of Representatives.

Due to the very short-range indoor environment, we assumed free-space propagation conditions. Consistent with previous analyses we also assumed the real-world antenna pattern depicted below and 3 dB of loss due to polarization mismatch.

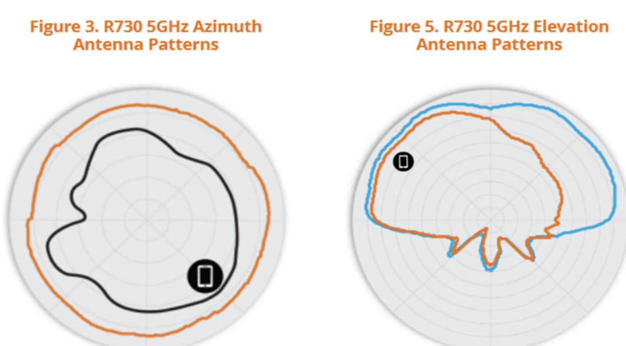

Figure 9 — Antenna Patterns.

With these assumptions, we calculated the received power level at each RLAN access point from an ENG transmitter located at any point in the House Chamber at each of three common ENG transmit power levels: 14, 20, and 24 dBm. The results of this simulation clearly demonstrate that, even at the lowest ENG power level, all RLAN access points would detect that signal at greater than -62 dBm and therefore not transmit co-channel at any reasonable ENG camera location in the Chamber, preventing harmful interference. At ENG transmit power levels of 20 and 24 dBm, all access points, with no exceptions, would detect the signal and not transmit.

The charts below provide a detailed depiction of our results:

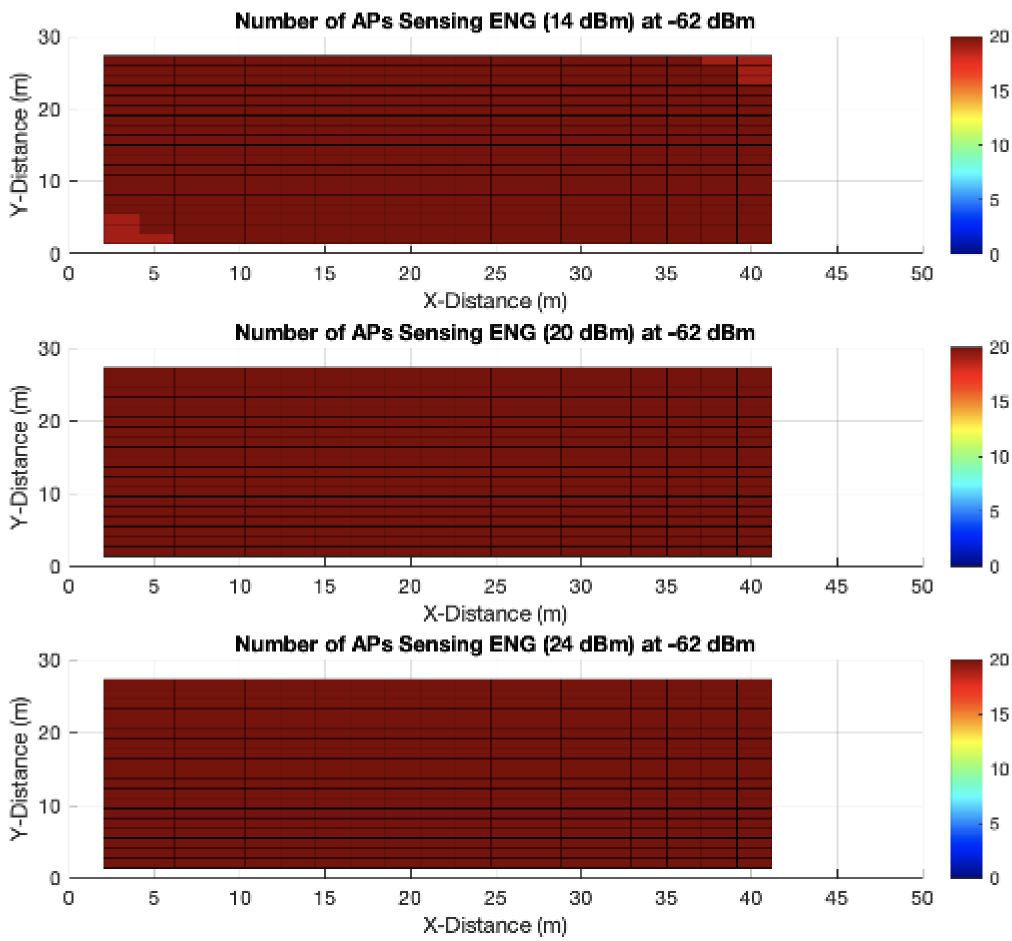

Figure 10 — Indoor ENG Simulation Results. Color encodes the number of RLAN access points that would detect and defer to an ENG transmitter at a given location.

These results demonstrate the role that RLAN clear-channel assessment will play in preventing harmful interference. In addition, they also highlight the very high probability that RLAN and ENG operations in this type of venue will be centrally coordinated. Not only will this central coordination prevent harmful interference to ENG receivers, it will also be necessary to ensure the basic functionality of a 6 GHz RLAN network because, as the simulation results above show, 6 GHz RLAN networks will perform very poorly in the presence of co-channel ENG operations.

IV. CONCLUSION

As we have previously explained, the NAB report is badly flawed and cannot be relied on. This new analysis further confirms the significance of the errors in NAB's report and demonstrates that, in fact, 6 GHz RLAN operations can coexist with broadcast operations without causing harmful interference.

Respectfully submitted,

Apple Inc.
Broadcom Inc.
Cisco Systems, Inc.
Facebook, Inc.
Google LLC
Hewlett Packard Enterprise
Intel Corporation
Microsoft Corporation
NXP Semiconductors
Qualcomm Incorporated